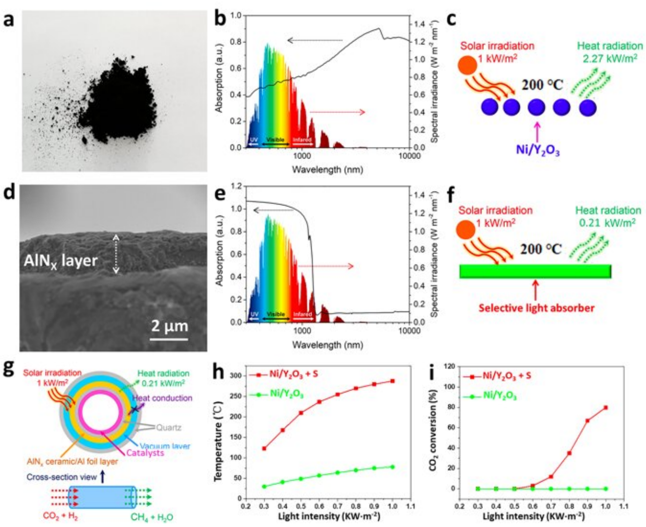
Using a selective light absorber to build a photothermal catalysis system

11 June 2019, by Ingrid Fadelli



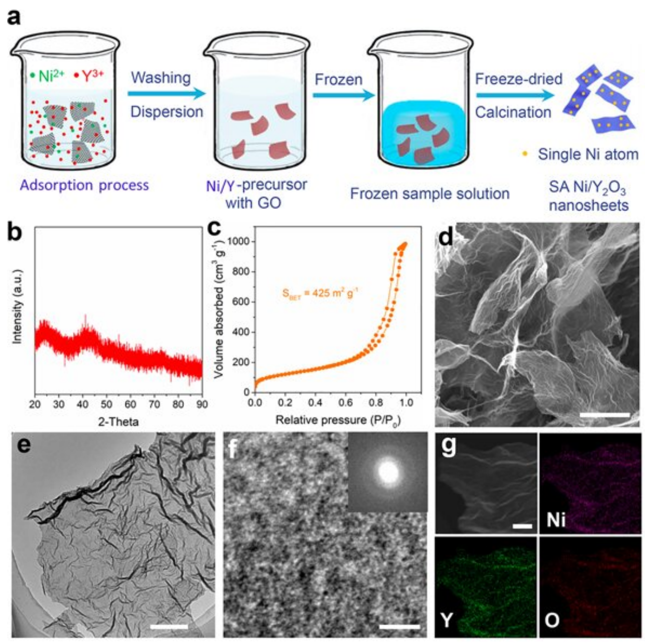
Credit: Li et al.

Researchers at Hebei University in China and Hakkaido University in Japan have recently used a selective light absorber to construct a photothermal system that can generate temperatures up to 288°C under weak solar irradiation (1 kW m^{-2}). This system, presented in *Nature Communications*, achieved a temperature three times higher than that generated by traditional phototermal catalysis systems.

"Our initial goal was to achieve outdoor sunlight-driven photothermal catalysis, but the thermal energy quality of solar thermal conversion is too low, i.e., the temperature is too low to be applied," Yaguang Li, one of the researchers who carried out the study, told Phys.org. "Therefore, we set the research direction in improving the temperature of photothermal materials under ambient sunlight irradiation."

Currently, the sunlight absorption capacity of photothermal materials is approaching its limit. In addition, ambient sunlight-driven CO_2 methanation is impossible to realize, as temperatures achieved by existing photothermal systems are typically lower than 80°C upon irradiation, with much solar energy being dispersed. To address this problem, Li and his colleagues set out to reduce the heat dissipation of photothermal materials in order to achieve greater concentration of heat energy inside them and consequently increase their temperatures.

When they discussed their idea with other researchers in the field, they realized that thermal radiation is a determining factor for heat dissipation in photothermal materials. However, as the thermal radiation of all photothermal materials is similar to black-body radiation, their thermal radiation cannot be reduced.



Credit: Li et al.

"We noticed the concept of selective light absorption, which is a classic concept, first proposed by Cabot in the 1940s," Li said. "In 1955, Shaffer et al., published the basic theory and design of selective light absorption coatings. Then, this selective light absorber started to be mass produced, applied on solar water heaters and other fields. However, no one has introduced this concept into photothermal catalysis, so we decided to do this. We found that this produced a magical effect—photothermal catalysis was realized just by outdoor sunlight radiation."

In their experiments, the researchers used a simple industrial selective light absorber to construct a photothermal catalytic reactor. This simple instrument enables the application of photothermal catalysis from strong light irradiation to weak light irradiation. In other words, this instrument significantly expands the range of possible applications for photothermal catalysis.

Li and his colleagues used the light absorber to create a photothermal system that can generate remarkably high temperatures. They also synthesized ultrathin amorphous Y_2O_3 nanosheets with confined single nickel atoms (SA Ni/Y_2O_3) and found that they exhibited substantial CO_2 methanation activity. Using the selective light absorber, they were able to achieve a CO_2 conversion efficiency of 80% and a CH_4 production rate of 7.5 L m^{-2} h^{-1} under ambient sunlight irradiation.

"In this work, we actually only used classic theories and mature factorized products," Li explained. "I think the greatest significance of this study for current science is that it encourages researchers to broaden their horizons and enhance communication with the industry. I feel that it could lead to tremendous progress in scientific applications."

In the future, the system proposed by Li and his colleagues could have interesting applications, for instance serving as a platform to directly harness dispersed solar energy and effectively convert CO_2 into valuable chemicals. The researchers are now planning to further improve the photothermal reactor used in their study, develop new catalysts that can are more suitable for photothermal catalysis and promote the industrialization of their proposed system.

More information: Yaguang Li et al. Selective light absorber-assisted single nickel atom catalysts for ambient sunlight-driven CO_2 methanation, *Nature Communications* (2019). DOI: 10.1038/s41467-019-10304-y

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